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Remarks

Applicants and their undersigned representative thank Examiner Walke for the very helpful and very courteous discussion on May 9, 2006. As discussed, Applicants submit herewith a Declaration from Dr. Joerg Rockenberger explaining why the cited reference (Hanabata et al., U.S. Pat. No. 6,921,623 [hereinafter "Hanabata et al."]) does not disclose or enable the claimed invention. The following remarks shall further summarize and expand upon topics discussed.

The present invention relates to a radiation patternable functional material, comprising nanoparticles of an electronically functional substance selected from the group consisting of semiconductors and metals, and a plurality of ligands bound to each of the nanoparticles. The ligands contain a photoreactive group or a group that is reactive with a photochemically generated species and that, after first-order photoreaction or reacting with the photochemically generated species, materially changes the solubility characteristics of the material in a developer. After irradiation, developing and curing, the present radiation patternable functional material forms a patterned film of an electronically conducting or semiconducting material.

Hanabata et al. neither discloses nor enables one to make a radiation patternable functional material comprising nanoparticles of an electronically functional substance selected from the group consisting of semiconductors and metals that can form a patterned film of an electronically conducting or semiconducting material after irradiation, developing and curing as (see Claim 1 as filed on December 12, 2005, and ¶¶ 5-6, 33 and 35 of the accompanying Declaration of Rockenberger). Consequently, the present claims are patentable over the cited reference.

The Rejection of Claims 1-20 under 35 U.S.C. § 102(e)

The rejection of Claims 1-20 under 35 U.S.C. § 102(e) as being anticipated by Hanabata et al. is respectfully traversed.

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Hanabata et al. discloses a photosensitive resin composition comprising an active component selected from an active metal alkoxide represented by the formula (1) or a polycondensate thereof and a particle represented by the formula (2):



wherein X (presumably) is a hydrogen, a halogen, an alkoxy group or an alkoxycarbonyl group, M (presumably) is a metal atom whose valence m is not less than 2, U₁ (presumably) is a first connecting unit, U² (presumably) is a second connecting unit and Z (presumably) is a group causing a difference in solubility by light exposure, P (presumably) is a fine particle carrier, Y (presumably) is a coupling residue, n (presumably) is an integer of not less than 1, m > n, p (presumably) is 0 or 1, t (presumably) is 1 or 2, k (presumably) is an integer of not less than 1, and s (presumably) is 0 or 1 (Abstract, ll. 1-16; see also ¶ 7 of the accompanying Declaration of Rockenberger). As is explained in the accompanying Declaration of Rockenberger, Hanabata et al. neither discloses nor suggests a radiation patternable functional material that forms a patterned film of an electronically conducting or semiconducting material, nor does Hanabata et al. enable one skilled in the art to make a radiation patternable functional material comprising nanoparticles of an electronically functional substance selected from the group consisting of semiconductors and metals (see ¶¶ 5-6 of the accompanying Declaration of Rockenberger), much less one that forms a patterned film of an electronically conducting or semiconducting material after irradiation, developing and curing. As a result, Hanabata et al. does not anticipate the present claims.

To anticipate a claim, a prior publication must contain all the essential elements of the claim. The prior publication must also be "enabling," meaning that it must place the allegedly disclosed subject matter in the possession of the public. *Scripps Clinic & Research Foundation v. Genentech, Inc.*, 707 F. Supp. 1547, 11 U.S.P.Q.2d 1187 (Fed. Cir. 1991), citing *Akzo N.V. v. U.S. International Trade Comm'n*, 808 F.2d 1471, 1479, 1 U.S.P.Q.2D (BNA) 1241 (Fed. Cir. 1986), cert. denied, 482 U.S. 909, 107 S. Ct. 2490, 96 L. Ed. 2d 382 (1987). Since Hanabata et al. do not place the subject matter of the present claims in the possession of the public, Hanabata

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et al. do not anticipate the present claims. Accordingly, this ground of rejection is unsustainable, and should be withdrawn.

The composition of Hanabata et al. is intended as a high-resolution photoresist material, not as an electronically conducting or semiconducting material. (See ¶ 8 of the accompanying Declaration of Rockenberger). For example, at col. 3, ll. 13-32, Hanabata et al. disclose that the combination of an active component and a photosensitive resin composition can form a high resolution pattern with high sensitivity when a functional group is introduced into the active component. Hanabata et al. further teach that a fine or finely divided particle (an active particle) can become hydrophilic by eliminating a hydrophobic leaving group upon light exposure, and the active component can be a specific metal alkoxide (an active metal alkoxide) or the polycondensate thereof (an active particle formed by polycondensation). Thus, according to Hanabata et al., light exposure can cause a difference in solubility, and the combination of the metal alkoxide or a polycondensate thereof, and a photosensitive resin composition, may form a high(er) resolution pattern with higher sensitivity because of a reduction of impurity incorporation. This disclosure of Hanabata et al. strongly suggests application of the composition disclosed therein as a photoresist. (See ¶ 9 of the accompanying Declaration of Rockenberger).

The invention of Hanabata et al. includes a photosensitive resin composition which comprises a base resin, a photosensitizer and the active component (col. 5, ll. 45-48; see also ¶ 10 of the accompanying Declaration of Rockenberger). To form a pattern, the photosensitive composition may be applied or coated onto a substrate, the coating layer may be exposed to light, the light-exposed layer may be heat-treated, and the heat-treated layer may be developed (col. 5, ll. 54-58 of Hanabata et al. and ¶ 10 of the accompanying Declaration of Rockenberger).

The active component (or ingredient) in the invention of Hanabata et al. is used (or usable) in combination with a photosensitizer which constitutes a photosensitive resin composition, and has a unit for causing a difference in solubility owing to at least light exposure (col. 6, ll. 27-31). The active component comprises at least one member selected from the group consisting of the active metal alkoxide represented by the formula (1) above or the

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polycondensate thereof, and the particle represented by the formula (2) above (col. 6, ll. 31-35 of Hanabata et al. and ¶ 11 of the accompanying Declaration of Rockenberger).

Although many possible metals are contemplated, Hanabata et al. teach that the metal atom M may be aluminum, titanium, zirconium or silicon, and is usually silicon (col. 4, ll. 33-34; emphasis added). This list of metals for metal atom M is consistent with the teachings of Hanabata et al. relating to the prior photoresist approach(es) discussed at col. 1, ll. 21-47 and col. 2, ll. 5-7. Thus, the photosensitive composition Hanabata et al. forms a patternable *resist* material, rather than a patterned electronically conducting or semiconducting material (see ¶ 12 of the accompanying Declaration of Rockenberger). Therefore, Hanabata et al. does not disclose a radiation patternable functional material comprising nanoparticles of an electronically functional substance selected from the group consisting of semiconductors and metals, having ligands bound thereto that can change the solubility characteristics of the material in a developer and *that forms a patterned film of an electronically conducting or semiconducting material* (see ¶ 13 of the accompanying Declaration of Rockenberger).

Furthermore, when their composition contains a particle or polycondensate, Hanabata et al. do not enable one to make a patternable material comprising semiconductor and/or metal nanoparticles having ligands bound thereto that can change the solubility characteristics of the material in a developer and that, after irradiation, developing and curing, can form a patterned film of an electronically conducting or semiconducting material. (See ¶ 14 of the accompanying Declaration of Rockenberger.)

Regarding the polycondensate, the polycondensate of Hanabata et al. may be a polycondensate of the active metal alkoxide represented by the formula (1) alone (singly) or a polycondensate (copolycondensate) of the active metal alkoxide represented by the formula (1) and a metal alkoxide represented by the following formula (5):



wherein R^5 represents a hydrogen atom or an alkyl group, and X, M, m and n have the same meanings as described in paragraph 7 above (col. 4, l. 65-col. 5, l. 8 of Hanabata et al.), although

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it is not clear how the compound of formula (5) can be a metal alkoxide when X is hydrogen, a halogen, or an alkoxycarbonyl group. In one embodiment, the polycondensate of Hanabata et al. is an active particle formed by polycondensation (col. 3, ll. 23-26). (See ¶ 15 of the accompanying Declaration of Rockenberger.)

Consistent with the disclosure described in the paragraph above, Hanabata et al. teach that an active component (especially an active particle) may comprise a polycondensate of the above-mentioned active metal alkoxide. Such an active component may be an active particle in the form of a particulate (particulate matter), or a liquid or solid oligomer. The active component [or, presumably] the polycondensate of the active component can be obtained by polycondensing the active metal alkoxide by a conventional sol-gel method to form of a polymer or a sol (col. 14, ll. 44-53). (See ¶ 16 of the accompanying Declaration of Rockenberger.)

As is known in the art, polycondensation (or polymerization) of metal alkoxides by the sol-gel method leads to formation of metal oxides, and not the corresponding metal (see ¶ 14 of the accompanying Declaration of Rockenberger). Therefore, any material, compound or composition based on the polycondensate of Hanabata et al. does not and cannot form a patterned film of an electronically conducting or semiconducting material after irradiation, developing and curing. (See ¶ 17 of the accompanying Declaration of Rockenberger.)

Regarding the particles, Hanabata et al. teach that the particle P (see formula (2) in paragraph 7 above) may be an organic fine particle carrier or an inorganic fine particle carrier (e.g., silicasol; see, e.g., col. 3, ll. 51-56; col. 5, ll. 17-19; and col. 17, l. 51-col. 18, l. 14). However, the organic fine particle carriers listed by Hanabata et al. at col. 17, ll. 51-61 (styrenic resins, [meth]acrylic resins, a silicone resin, thermosetting resins such as polyamide resins, a crosslinked melamine resin and a crosslinked guanamine resin) do not and cannot form a patterned film of an electronically conducting or semiconducting material after irradiation, developing and curing. (See ¶ 18 of the accompanying Declaration of Rockenberger.)

In the passage at col. 18, ll. 1-14, Hanabata et al. disclose a number of inorganic fine particle carriers, including a metal alone (simple or single metal; e.g., gold, silver, copper, platinum, aluminum), an inorganic oxide (e.g., silica [e.g., silica sol such as colloidal silica,

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acrogels, glass], alumina, titania, zirconia, zinc oxide, copper oxide, lead oxide, yttrium oxide, tin oxide, indium oxide, magnesium oxide), an inorganic carbonate (e.g., calcium carbonate and magnesium carbonate), an inorganic sulfate (e.g., barium sulfate and calcium sulfate), a phosphate (e.g., calcium phosphate and magnesium phosphate), and the like, which include sols and gels prepared by, for example, a sol-gel method, and which can be used either singly or in combination. Thus, out of the five generic inorganic fine particle carrier types (not including the sols and gels), all but one are clearly expected to form an electrical insulator after functionalization (i.e., formation of the compound of formula (2) from the particle), irradiation, developing and curing. (See ¶ 19 of the accompanying Declaration of Rockenberger.)

In the one remaining example of a particle (a metal alone), Hanabata et al. do not enable one to form a patterned film of an electronically conducting or semiconducting material after irradiation, developing and curing of a composition including a compound having a metal particle. This is because Hanabata et al. discloses and enables formation of an insulator film or a somewhat random distribution of particles (which may or may not have properties of a metal) embedded in an insulator matrix, rather than a patterned film of an electronically conducting or semiconducting material. (See ¶ 20 of the accompanying Declaration of Rockenberger.)

For example, to form the particles of formula (2) above, Hanabata et al. enable use of only particles (be they organic or inorganic) having hydroxide (or a combination of hydroxide and oxide) groups on the surface for linking to a coupling agent residue Y. Hanabata et al. teach that a hydrophilic group is introduced into an inorganic fine particle through both a coupling agent and a connecting unit (col. 16, ll. 63-65). Each component may be bonded by reacting a connecting unit U having two hydroxyl groups with a coupling agent Y having an isocyanate group (e.g., a silane coupling agent) to form a compound having a free hydroxyl group and a coupling group (an alkoxy group or a halogen atom), wherein the coupling agent is bonded to one of hydroxyl groups of the unit; protecting the free hydroxyl group by a protective group such as t-BOC group; and then reacting an inorganic fine particle carrier (e.g., silicasol, etc.) with the coupling group (the alkoxy group or the halogen atom; see col. 16, l. 65-col. 17, l. 9). Other processes may be employed, but they also appear to bind the hydrophilic group-containing

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compound with the particle via the alkoxy group or halogen atom site in the coupling agent (see, e.g., col. 17, ll. 10-30 of Hanabata et al.). Thus, Hanabata et al. teach that an alkoxy group or halogen atom in the coupling agent is required for introducing the hydrophilic group (i.e., the group giving the composition its photosensitive properties; see, e.g., col. 3, l. 66-col. 4, l. 17) into a fine particle (be it an inorganic particle or another type of particle). (See ¶ 21 of the accompanying Declaration of Rockenberger.)

Specifically with regard to the inorganic particle, Hanabata et al. disclose examples of coupling agents (corresponding to a residue Y in formula (2) above) including an organic metal compound containing an alkaline earth metal, a transition metal, a rare earth metal, or a metal element of the Groups 3 to 5 and 13 to 15 of the Periodic Table of Elements, especially a metal element of the Groups 4, 13 and 14 of the Periodic Table of Elements, for example, aluminum, titanium, zirconium, and silicon. Among the organic metal compounds, a titanium coupling agent and a silane coupling agent (especially the silane coupling agent) are preferred (col. 18, l. 41-51). (See ¶ 22 of the accompanying Declaration of Rockenberger.)

The silane coupling agent includes the coupling agents represented by the formula (4):



The reactive group D corresponding to the fine particle carrier of the coupling agent (4) is usually a halogen atom (bromine atom, chlorine atom, etc.), or a hydrolytic condensable group such as an alkoxy group (e.g., a C_{1-n} alkoxy group such as methoxy group and ethoxy group; see col. 18, ll. 52-59 of Hanabata et al.). As is known in the art, many metal halides such as TiCl₄ and SiCl₄ are reactive towards oxygen-containing compounds (see, e.g., Cotton et al., "Advanced Inorganic Chemistry," John Wiley & Sons, New York (1999), pp. 271-272, 283-285, 472-474, and 558-559, attached hereto), and the hydrolytic condensable groups of Hanabata et al. result in the formation of metal-oxygen-silicon bonds, typically from a hydroxy group on the metal. Thus, the silane coupling agents disclosed by Hanabata et al. are known to be reactive with the oxygen-containing species, such as oxo or hydroxy groups (which are bound directly to a metal;

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i.e., metal oxides and/or hydroxides; see ¶¶ 23-24 of the accompanying Declaration of Rockenberger).

On the other hand, the silane coupling agents disclosed by Hanabata et al. are not expected to react with metal or semiconductor particles not having oxygen-containing species on the surface (at least not in any manner that would result in formation of a compound of the formula (2) above; see ¶ 25 of the accompanying Declaration of Rockenberger). For example, of the five (5) metals disclosed by Hanabata et al. at col. 18, ll. 1-3, three (3) are generally considered not to form significant amounts of oxide on corresponding particle surfaces (i.e., gold, silver and platinum; see ¶ 26 of the accompanying Declaration of Rockenberger). Based on the disclosures of Hanabata et al. discussed in the accompanying Declaration, Hanabata et al. do not enable coupling of a coupling agent to metal particles that do not form oxide surfaces. Instead, and as an example of why such a coupling reaction as taught by Hanabata et al. would fail, an attempt to couple the silane coupling agent to such metal particles under state of the art coupling conditions would be likely to crosslink the silane coupling agent, rather than couple it to the metal nanoparticle. Thus, if the "metal alone" particle of Hanabata et al. is capable of coupling with the silane coupling agent in the manner disclosed therein, the "metal alone" particle of Hanabata et al. must be one that contains a sufficiently large number of hydroxide and/or oxide groups on its surface to enable the coupling reaction to occur to an extent enabling isolation of the coupling reaction product. However, the silane cross-linking reaction consumes twice as much coupling agent as the coupling reaction, and is reasonably expected to have a faster reaction rate than the coupling reaction, so one would not expect a reaction between particles of gold, silver or platinum alone and the silane coupling agent of formula (4) above to result in an amount of coupling reaction product that can be reasonably isolated. As a result, and consistent with the remainder of their disclosure, Hanabata et al. does not enable formation of particles of the formula (2), where P is a particle of gold, silver or platinum alone. (See ¶ 26 of the accompanying Declaration of Rockenberger.)

The remaining metals disclosed by Hanabata et al. at col. 18, ll. 1-3 (copper and aluminum) readily form oxide surfaces (e.g., on exposure to air, oxygen or other oxygen-

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containing oxidant such as hydrogen peroxide). As a result, copper or aluminum metal particles as disclosed by Hanabata et al. would be expected to have a sufficiently large number of oxide and/or hydroxide groups on their surfaces to couple to the silane coupling agent in the manner disclosed and taught by Hanabata et al. and provide an amount of coupling reaction product that can be reasonably isolated. Such a large number of oxide and/or hydroxide groups on the surface of a copper or aluminum particle would effectively prevent formation of patterned film of an electronically conducting or semiconducting material, after irradiation, developing and curing, particularly after functionalization with the coupling agents, U_1/U_2 connecting units and light-sensitive Z functional groups (see formula (2) above and the discussion of cross-linking vs. coupling reactions in ¶¶ 26-27 of the accompanying Declaration of Rockenberger).

Once functionalized in the manner taught by Hanabata et al., the composition of Hanabata et al. forms an insulator film or a distribution of particles embedded in an insulator matrix, rather than a patterned film of an electronically conducting or semiconducting material. For example, the active (or photoactive) component of Hanabata et al. (i.e., the active metal alkoxide, its polycondensate, and/or an active particle represented by the formulas (1) and (2)) is advantageously used (usable) in combination with a photosensitive resin composition (col. 20, ll. 60-67; emphasis added). The photosensitive resin (or resist) composition of Hanabata et al. may comprise a photosensitizer and the above-mentioned active component, but usually it comprises a base resin (an oligomer or a polymer), a photosensitizer and the above-mentioned active component (col. 21, ll. 50-55). Of the resins listed from col. 21, l. 56 through col. 25, l. 43, none are known to result in formation of a patterned film of an electronically conducting or semiconducting material. Instead, these resins are generally known to form an insulator film (or in the case where particles are present, a distribution of particles embedded in an insulator matrix) after irradiation, developing and curing (see ¶ 28 of the accompanying Declaration of Rockenberger).

For example, Hanabata et al. teach that the amount of the active component in their photosensitive resin composition can be from about 0.01 to 1000 parts by weight, on a solid matter basis, relative to 100 parts by weight of the base resin. The amount of active component

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is usually from about 5 to 1000 parts by weight, preferably about 10 to 500 parts by weight and more preferably about 10 to 300 parts by weight, especially about 10 to 100 parts by weight, relative to 100 parts by weight of the base resin on a solid matter basis. (Col. 27, ll. 14-23 of Hanabata et al.) As a result, when the photosensitive resin composition of Hanabata et al. further includes a base resin, the photosensitive resin composition of Hanabata et al. forms an insulator film or (in the case where particles are present) a distribution of particles embedded in an insulator matrix, after irradiation, developing and curing (see ¶ 29 of the accompanying Declaration of Rockenberger).

The photosensitive resin composition of Hanabata et al. can be prepared in accordance with a conventional method, for example, by mixing a photosensitive resin [a base resin and a photosensitizer] and an active component. The photosensitive resin composition usually contains a solvent (e.g., the solvents exemplified in the section of the active metal alkoxide). (Col. 27, ll. 33-45 of Hanabata et al., and ¶ 30 of the accompanying Declaration of Rockenberger). The photosensitive layer of Hanabata et al. can be formed by applying (spreading or coating) the above-described photosensitive resin composition to a substrate (a base material; see col. 27, ll. 47-49 of Hanabata et al.), and patterns can be carried out by a conventional lithography technique (i.e., a combination of exposure, development and etching; see col. 28, ll. 52-54 of Hanabata et al.). Hanabata et al. also teach that their coated film may be subjected to heat- or cure-treatment at a suitable temperature in an appropriate step from application of the photosensitive resin composition to development. If necessary, for example, after development, the coated film of Hanabata et al. may be subjected to heat-treatment (col. 29, ll. 61-67 of Hanabata et al.), but no particular temperature, temperature range or temperature effective to provide a desired result is disclosed. Thus, when the photosensitive resin composition of Hanabata et al. includes a base resin, it is expected to form an insulator film or (in the case where particles are present) a distribution of particles embedded in an insulator matrix, after irradiation, developing and curing (see ¶ 31 of the accompanying Declaration of Rockenberger).

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However, even if the active component (i.e., compound[s] of the formulas (1) and (2) above) is used without a base resin as the photosensitive resin composition (although Hanabata et al. does not disclose any examples of such a composition), those particles P disclosed by Hanabata et al. that are capable of coupling to the coupling agent in a manner enabling reasonable isolation of a compound of the formula (2) would be expected to form a distribution of particles embedded in an insulator matrix, after irradiation, developing and curing. The particles of formula (2) capable of being made in an amount that can be reasonably isolated would not be capable of forming a patterned film of an electronically conducting or semiconducting material after irradiation, developing and curing (see ¶ 32 of the accompanying Declaration of Rockenberger).

Consequently, all of the particles (organic, inorganic or metal) disclosed by Hanabata et al. form oxides or other electrical insulators after functionalization with the coupling agent, irradiation, developing and curing (¶ 33 of the accompanying Declaration of Rockenberger). Hanabata et al. disclose no reaction, technique or special set of conditions under which their silane coupling agent(s) are capable of forming a particle having photosensitive ligands bound thereto that is capable of forming a patterned film of an electronically conducting or semiconducting material after irradiation, developing and curing (¶ 33 of the accompanying Declaration of Rockenberger).

As an alternative to the silane coupling agent, the organic metal compounds of Hanabata et al. containing, as the metal M, aluminum, titanium or zirconium, may be exemplified by the organic metal compounds corresponding to the silane coupling agents (col. 19, ll. 3-7). Thus, the possibility of metals other than silicon in the coupling agent of Hanabata et al. does not enable formation of a radiation patternable functional material comprising nanoparticles of an electronically functional substance selected from the group consisting of semiconductors and metals, and a plurality of ligands bound to each of the nanoparticles, that forms a patterned film of an electronically conducting or semiconducting material after irradiation, developing and curing (see ¶ 34 of the accompanying Declaration of Rockenberger).

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Therefore, Hanabata et al. does not enable one skilled in the art to make a radiation patternable functional material comprising nanoparticles of an electronically functional substance selected from the group consisting of semiconductors and metals, having ligands bound thereto that can change the solubility characteristics of the material in a developer and that forms a patterned film of an electronically conducting or semiconducting material (§ 35 of the accompanying Declaration of Rockenberger).

Furthermore, Hanabata et al. further teach the importance of a transparent particle. For example, when the mean particle size of the active particle is smaller than an exposing wavelength, because the active particle is substantially transparent to the exposing wavelength, light exposure can be conducted to the depth of the photosensitive layer even if the layer is thickened (col. 15, ll. 56-60). As a result, sensitivity and resolution can be improved as much as a pattern with high sensitivity and high resolution can be formed in regard to a light source of shorter wavelength (col. 15, ll. 60-63). These disclosures by Hanabata et al. further emphasize the application of the compounds of formulas (1) and (2) above to photolithography and photoresist compositions (§ 36 of the accompanying Declaration of Rockenberger).

The use of UV-absorbent metal nanoparticles may be detrimental to the suggested advantages of the invention of Hanabata et al. While it is generally understood in the art that nanoparticles having a size less than 100 nm do not scatter light (assuming they are not agglomerated in larger secondary particles), many metal nanoparticles (in particular gold, silver, and copper) have one or more strong characteristic UV absorptions. These absorptions would be expected to reduce the sensitivity of the resist of Hanabata et al., and limit its usefulness for high resolution patterning (§ 37 of the accompanying Declaration of Rockenberger).

Therefore, Hanabata et al. neither discloses nor enables a radiation patternable functional material comprising nanoparticles of an electronically functional substance selected from the group consisting of semiconductors and metals, having ligands bound thereto that can change the solubility characteristics of the material in a developer and that forms a patterned film of an electronically conducting or semiconducting material (see Claim 1). Consequently, this ground of rejection is unsustainable, and should be withdrawn.

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Conclusions

In view of the above amendments and remarks, all bases for objection and rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

If it is deemed helpful or beneficial to the efficient prosecution of the present application, the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,



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